GIS For The Petroleum Industry

Ken Hood
Ulf Becker
November 15, 2017

About us…

- Ulf Becker
  - BS, Geology, University of Kansas, 1993
  - MS, Geology, Northern Arizona University, 1996
  - Kansas Geological Survey, 1996-97
  - ExxonMobil, 1997-present
  - Currently Enterprise GIS Advisor and Senior Technical Professional for GIS in ExxonMobil IT
- Ken Hood
  - BS, Geology, University of Missouri-Columbia, 1983
  - MS, Geology, University of Kansas, 1985
  - PhD, Geology, University of Kansas, 1989
  - ExxonMobil, 1988-present
- All map examples & data are hypothetical and/or vendor supplied

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Disclaimer

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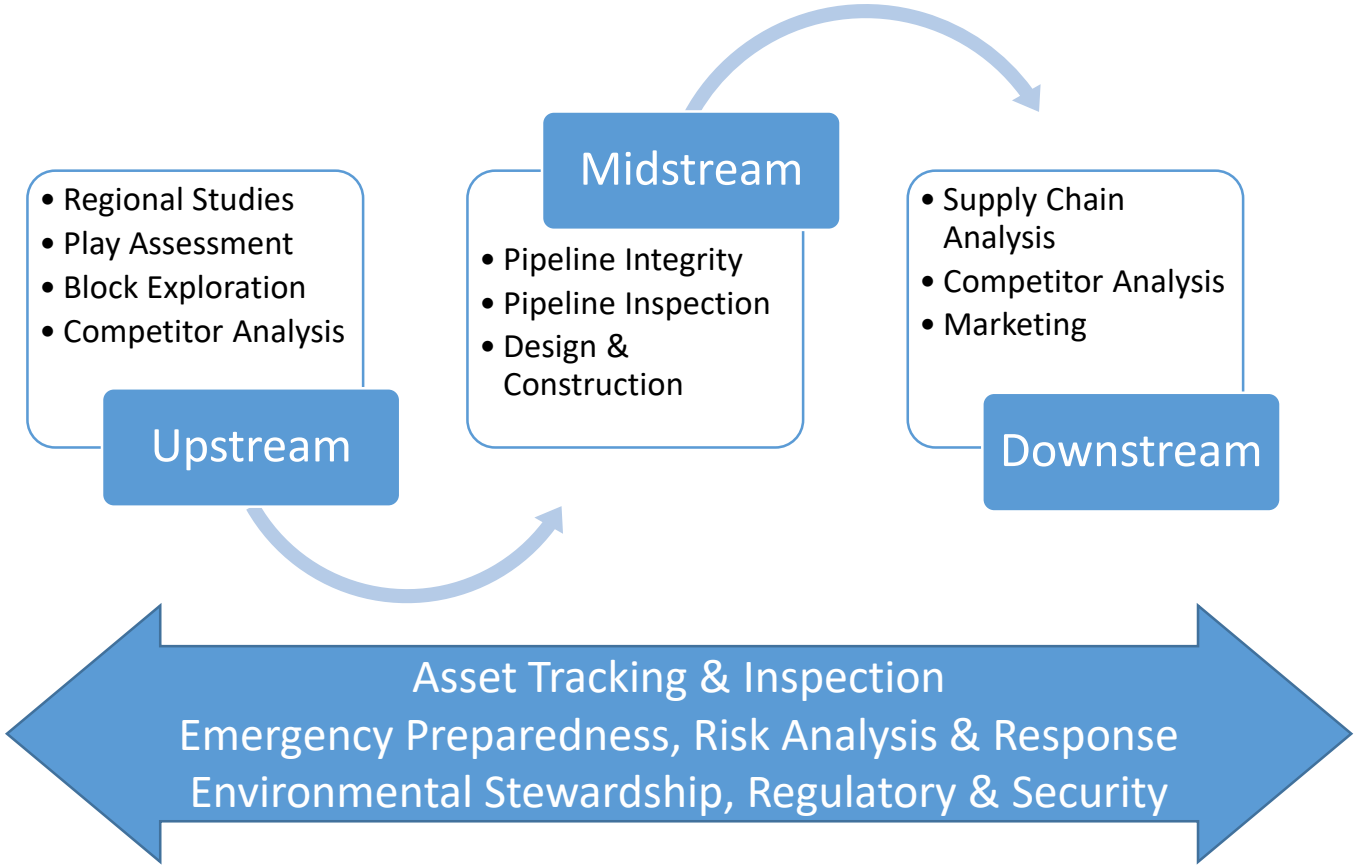
Why GIS in oil & gas?

Provides **spatial awareness** and **location analytics** required for **decision making** across the entire industry



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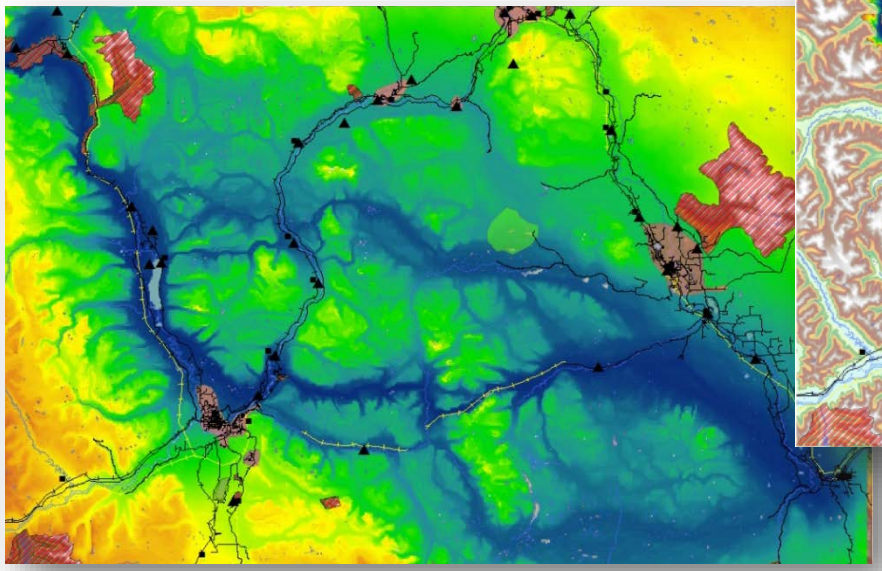
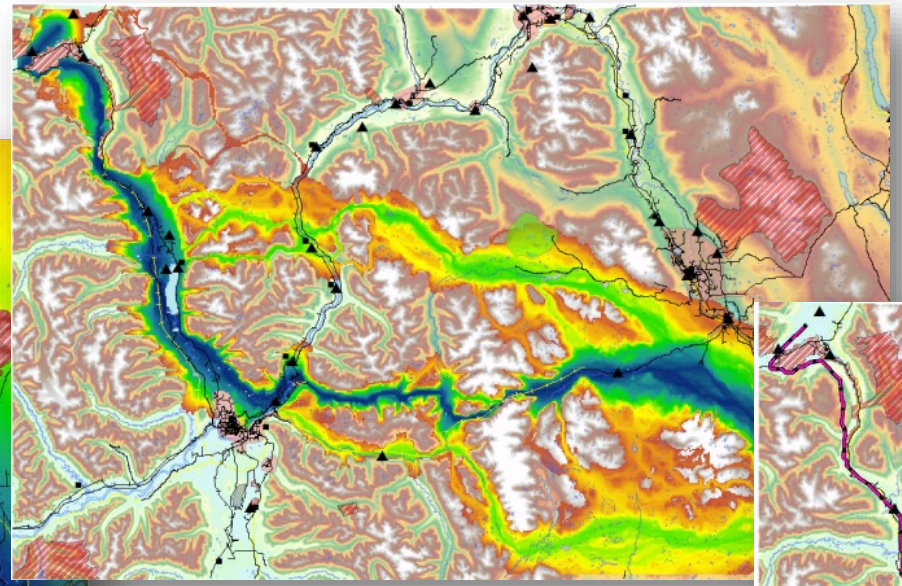
Pipeline

- Design and construction

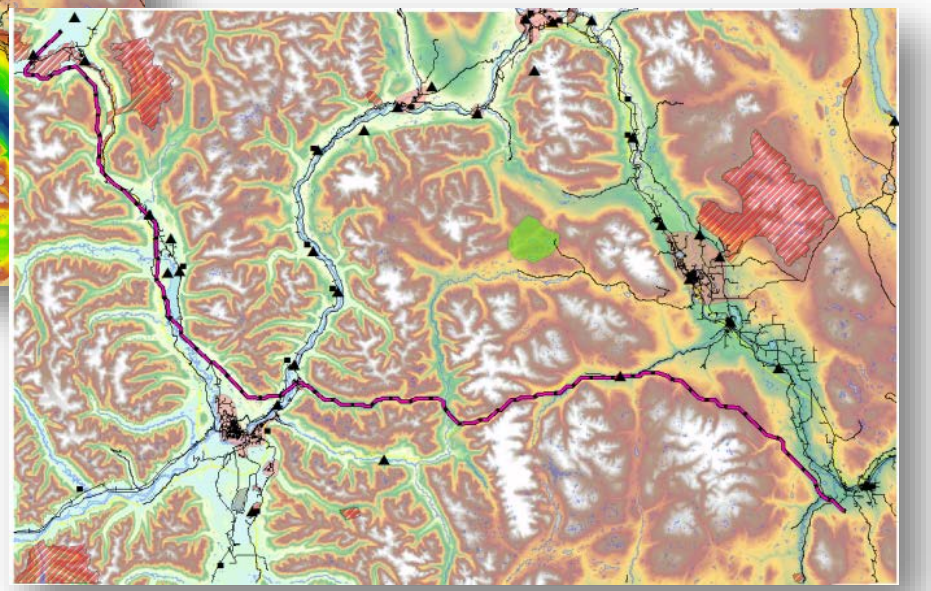


Suitability grid assigned across AOI based on required parameters

Suitability analysis is constrained & refined



Final route defined based on cost analysis



ExxonMobil demonstration data

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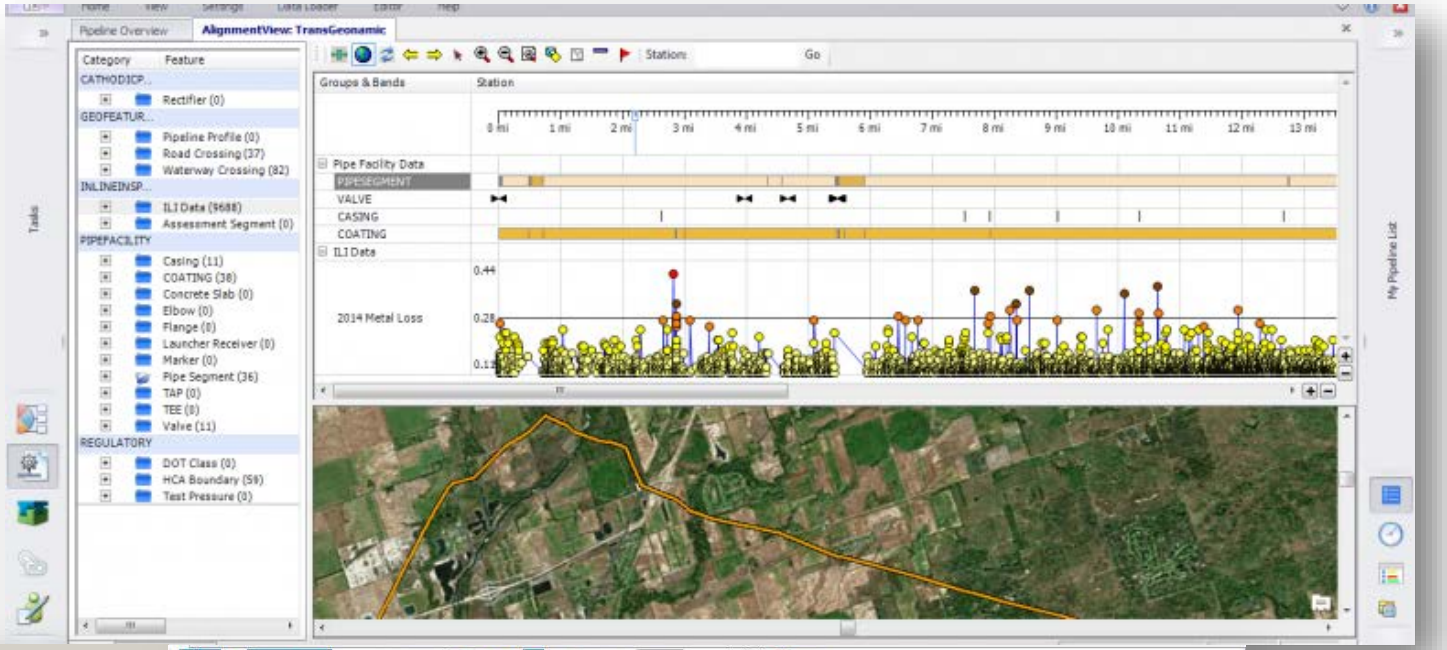
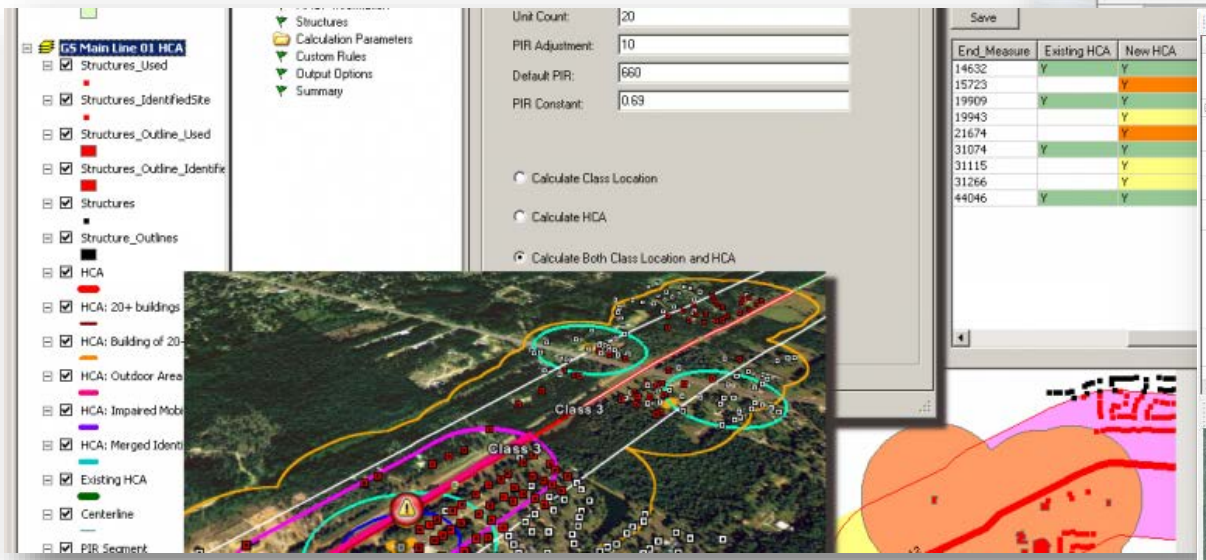
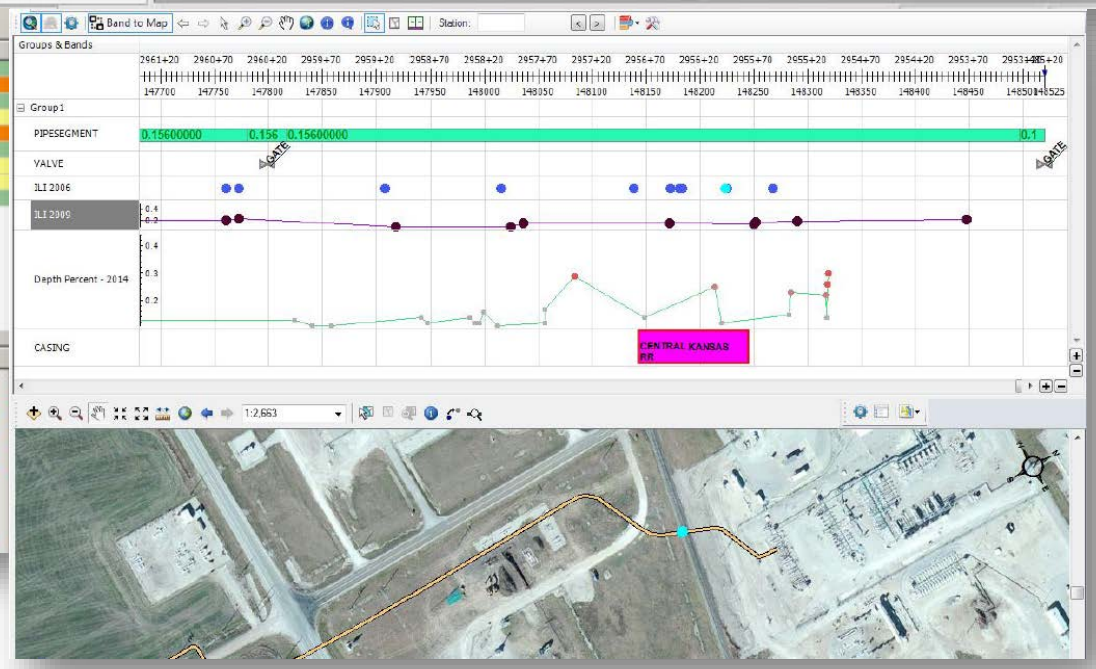
Pipeline

- One Call
- Inline Inspection
- Field Inspection







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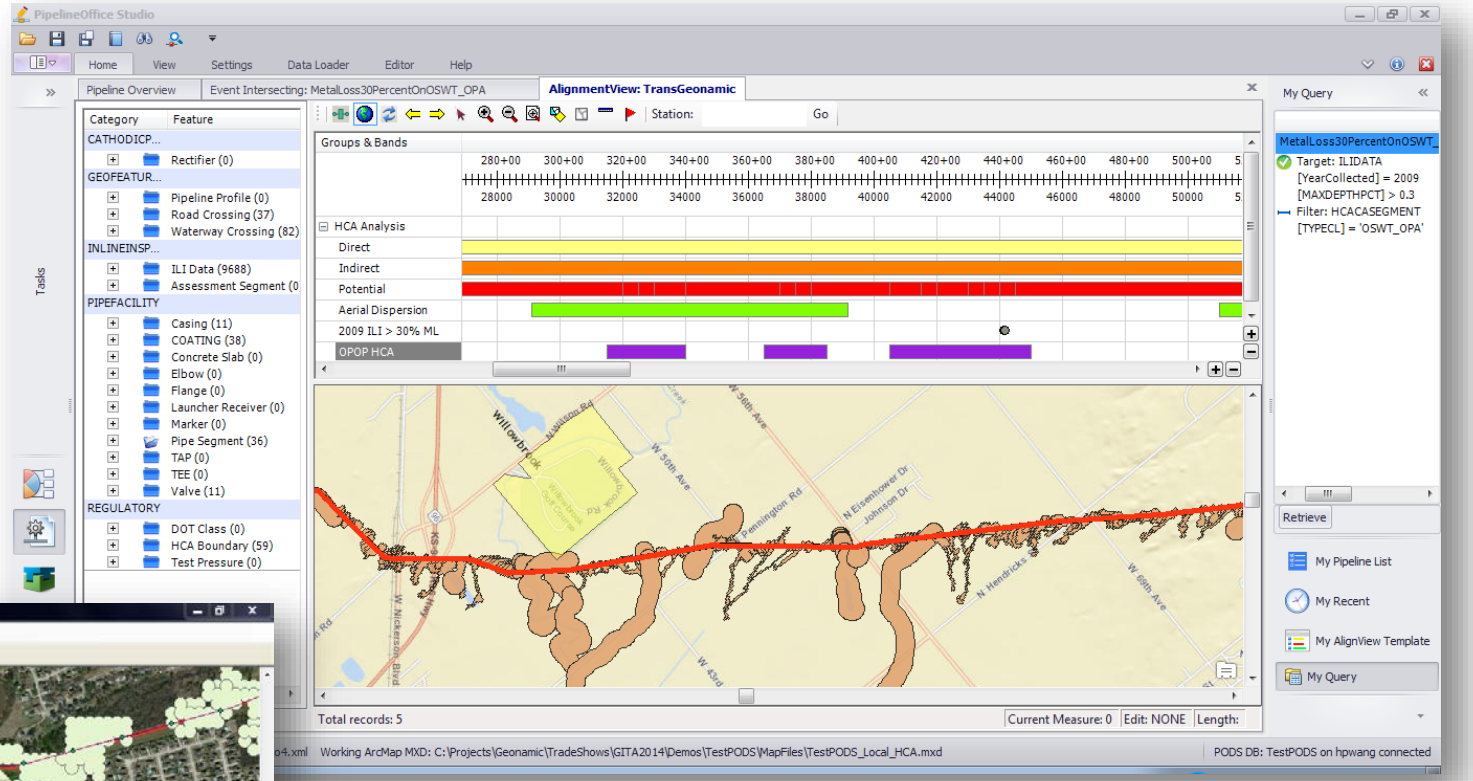
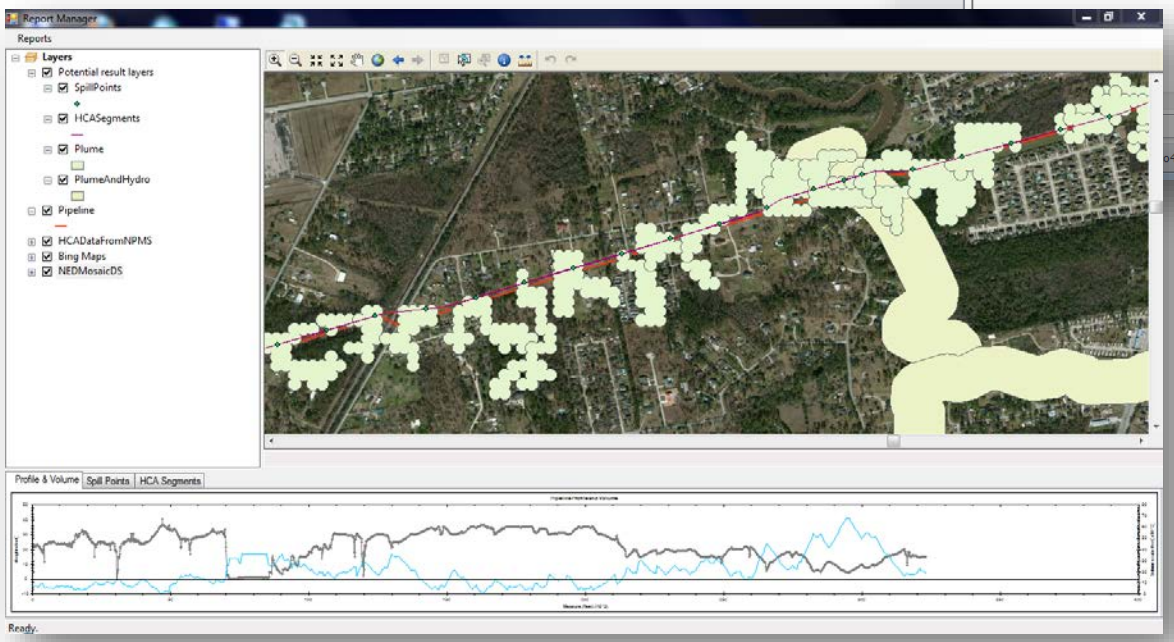
Screen captures courtesy of Geonamic

Pipeline

- Risk Analysis & Emergency Response





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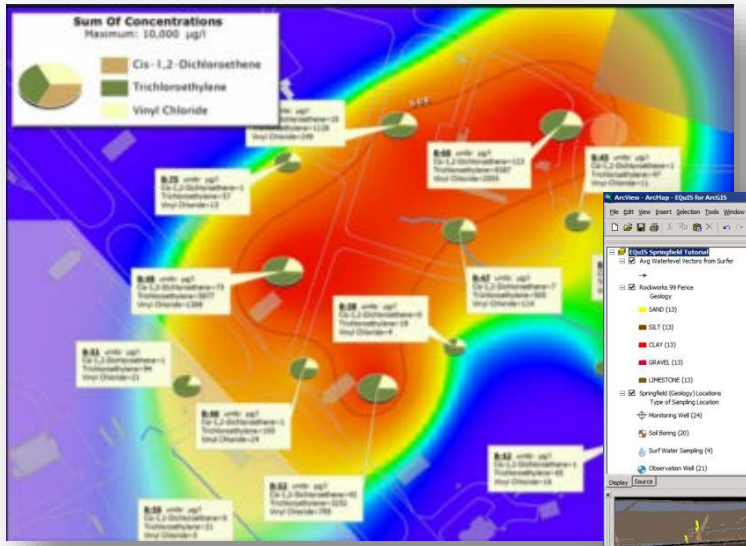
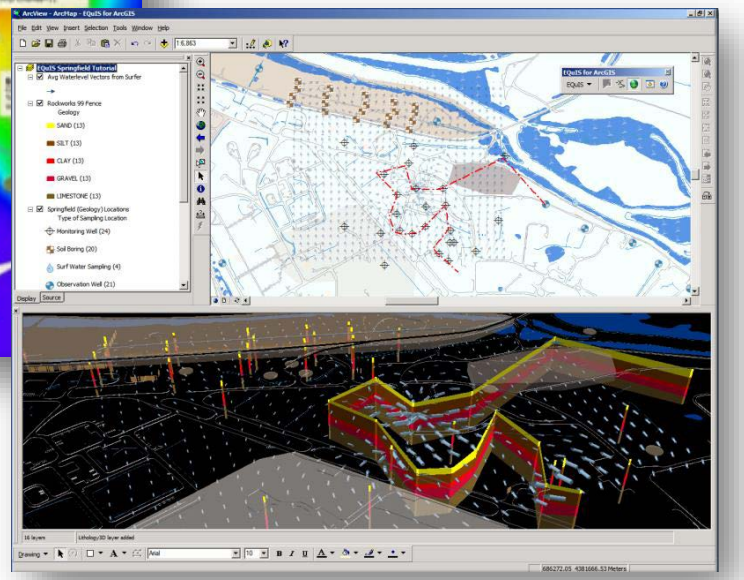
Screen captures courtesy of Geonamic

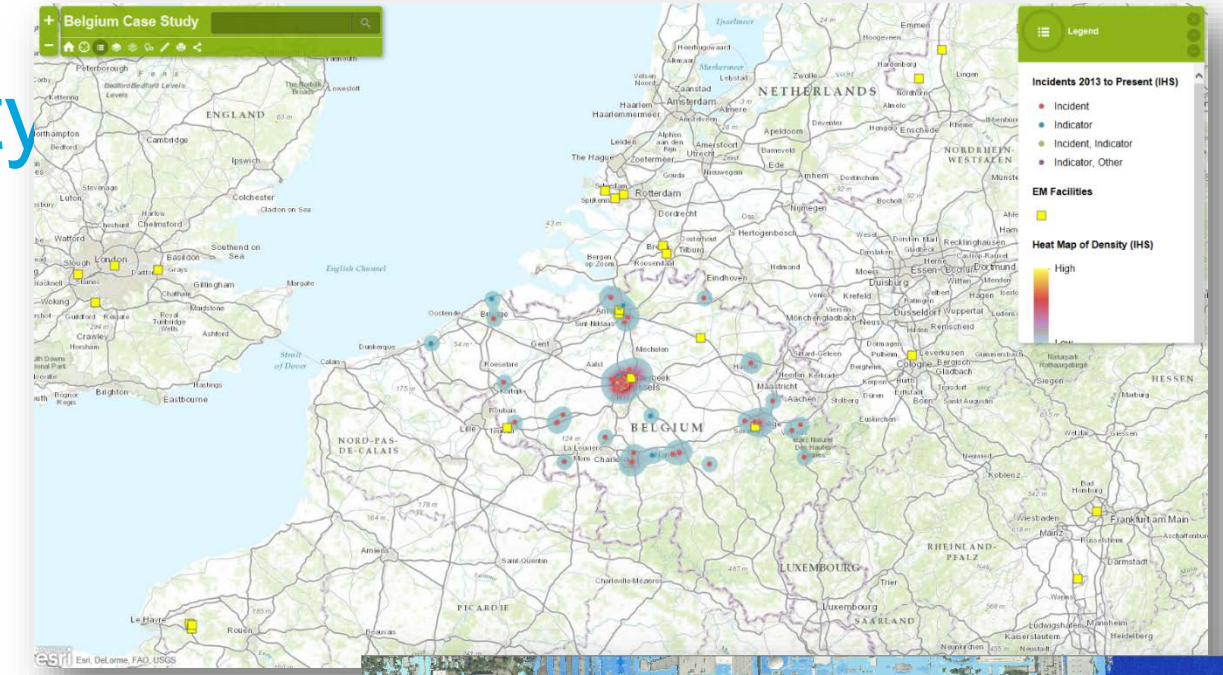
Environmental & Security

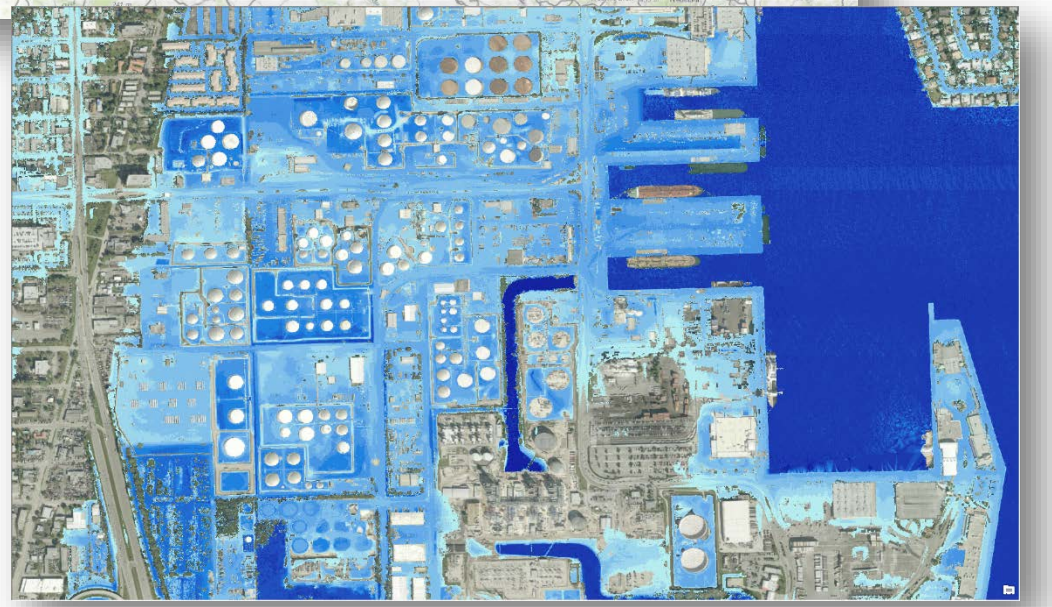
- Site Risk Analysis
- Regulatory
- Emergency Response





Screen captures courtesy of Earthsoft





ExxonMobil demonstration data

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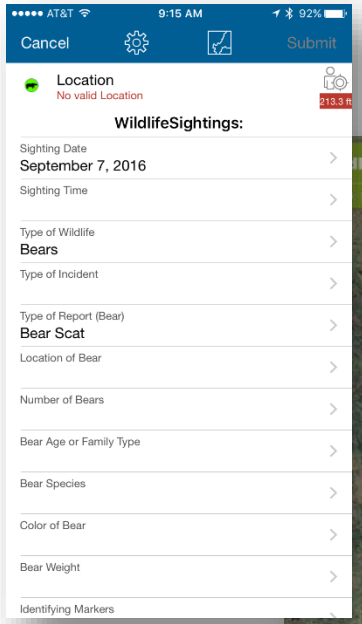
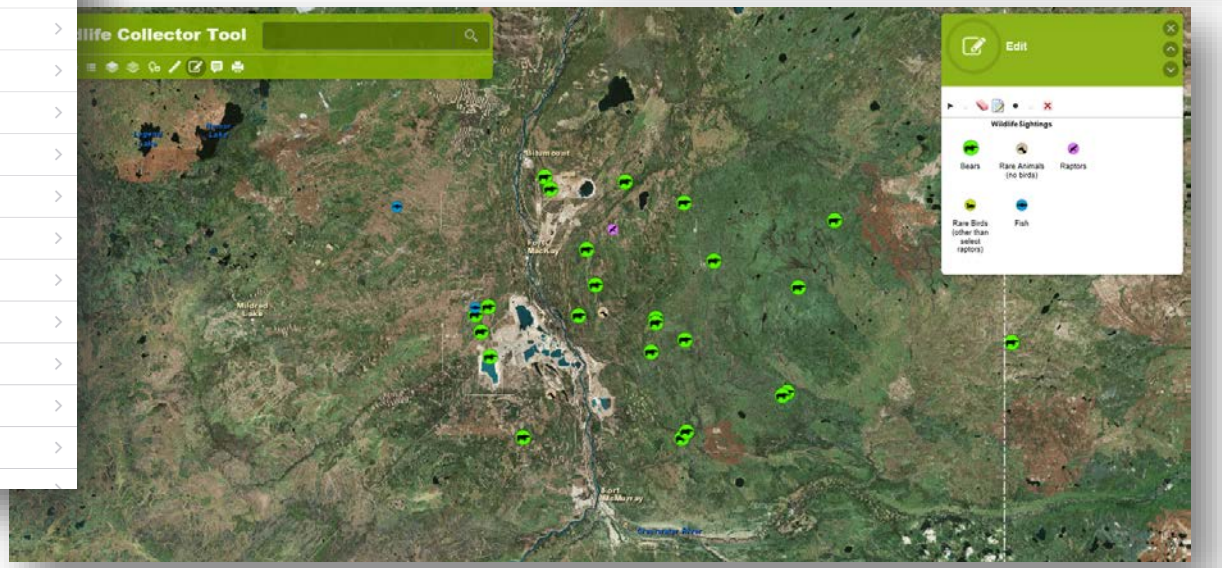
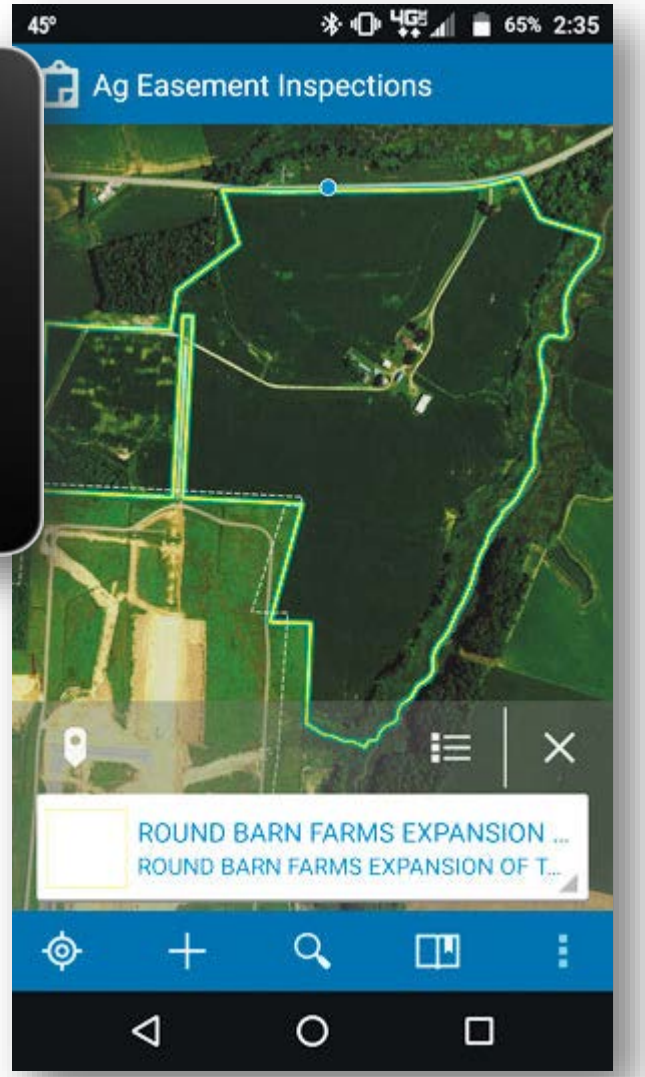
Mobile GIS

- Wildlife Sightings & Management
- Asset Inspection





ExxonMobil demonstration data



Screen captures courtesy of Esri

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A few observations

- “GIS” is an outdated phrase
  - “Traditional” GIS – ArcGIS, Global Mapper, GRASS, MapInfo
  - Consumer grade – Apple Map, Bing Map, Google Map
  - Pipeline – GeoFields, Geonamic, New Century
  - Environmental – EQuIS, Oil Map
  - Utilities – Smallworld
  - Geoscience – Kingdom, Petra, Petrel
- GIS as a profession/degree/specialty versus GIS as a tool
  - Both are important for industry
  - GIS specialists are required to build and maintain solutions
  - Other disciplines should understand use of GIS (see above!)
- Familiarity with geodetic principles

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Using GIS to Manage Hydrocarbon Opportunities

- The spatial and stratigraphic distribution of Discovered (fields) and Undiscovered (prospects) hydrocarbons is strongly influenced by the underlying geology controls
- Understanding the geologic controls on hydrocarbon potential requires linking targets to specific stratigraphic intervals
- Understanding the business value on an opportunity requires aggregating hydrocarbon pools and potential across multiple stratigraphic intervals
  - The business value also must reflect the development status of a potential target (untested, discovered undeveloped, enhanced recovery, etc)
- GIS provides a powerful framework in which to manage know and future potential hydrocarbon opportunities
  - An integrated, spatial and stratigraphically enabled database for fields, prospects, and dry tests

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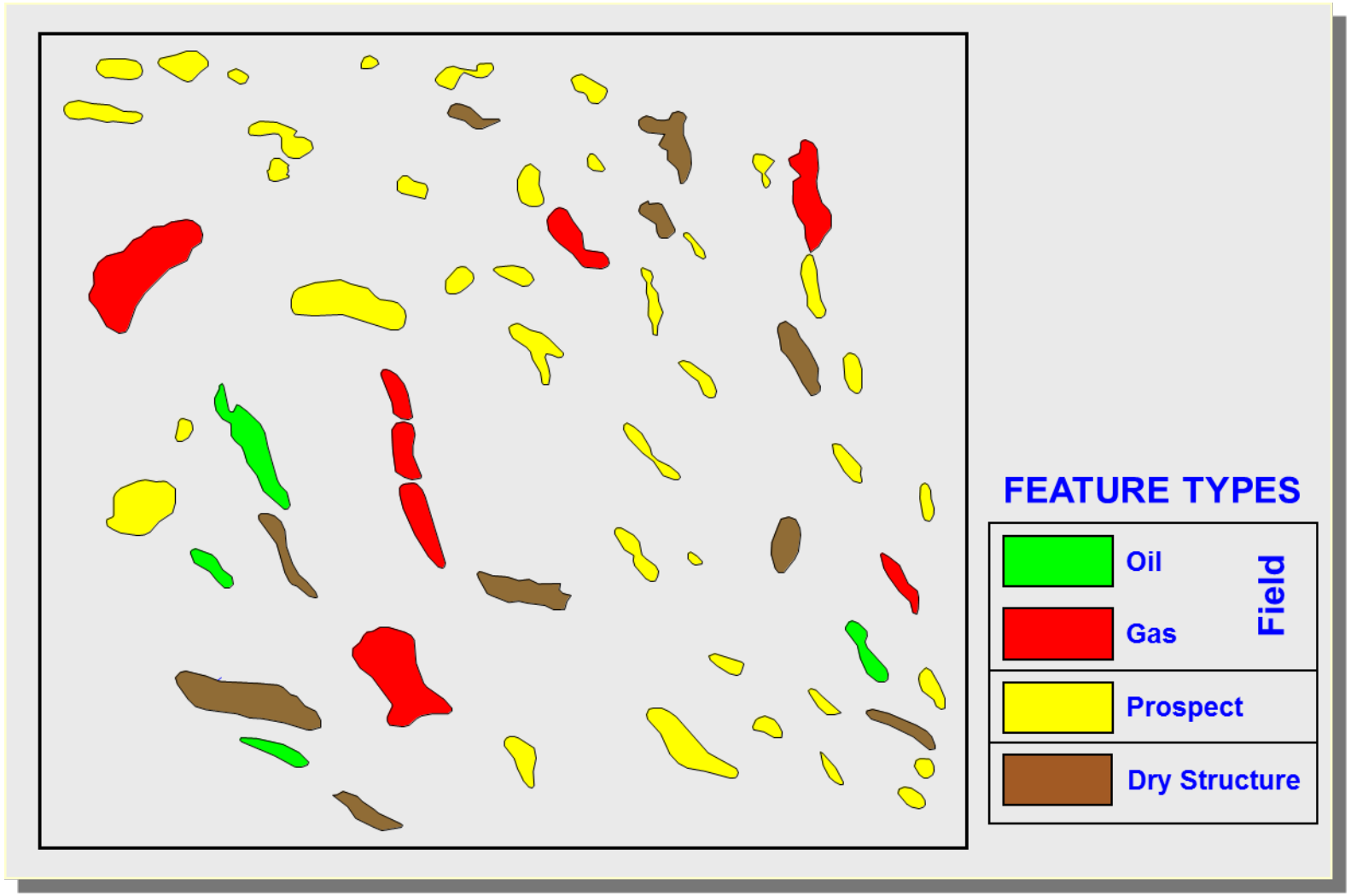
Managing Database of Drilled and Undrilled Opportunities



- The opportunity space for conventional hydrocarbon exploration comprises successful (fields), failed (dry tests), and untested traps (prospects)
- Traditional approach is store these different feature types in separate databases
- Integrating these feature types into a single database provides considerable benefits
  - Accommodates complex compartmentalization both vertically (stratigraphically) and spatially

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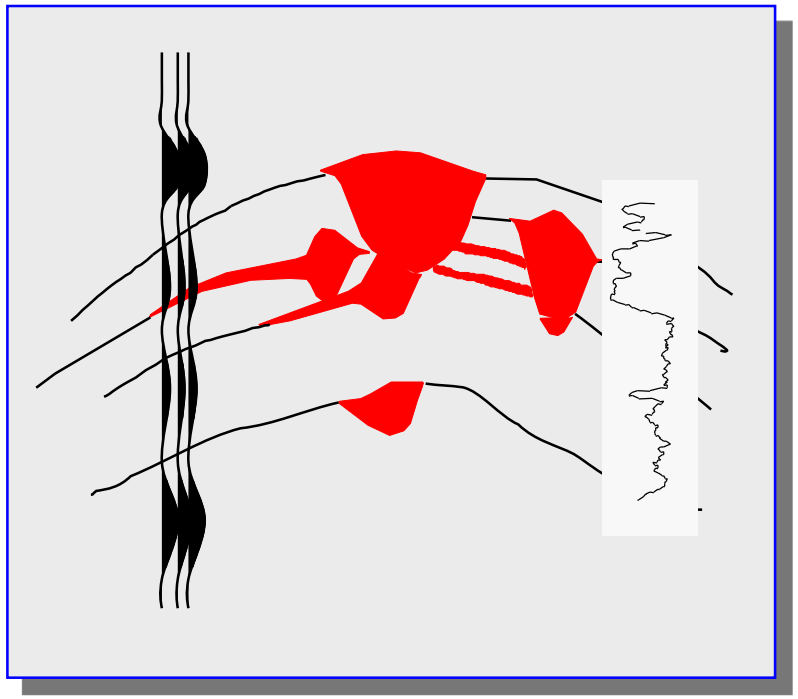
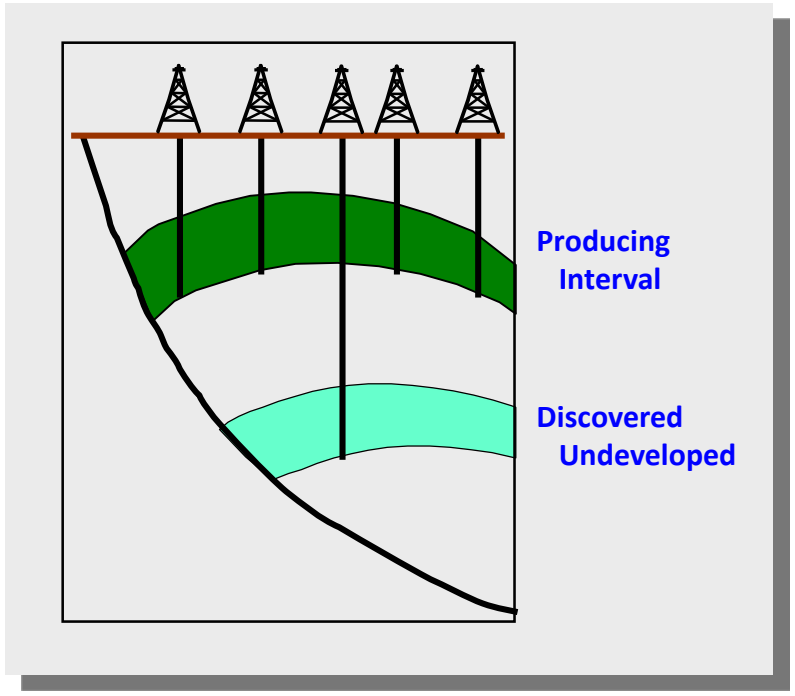
After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Feature Complexities – Level of Detail



Level of Detail --
Wells versus Seismic



Level of Detail --
Producing versus Undeveloped

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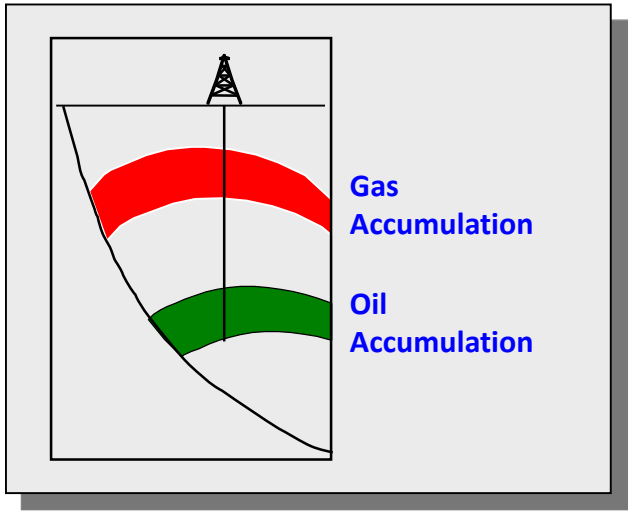
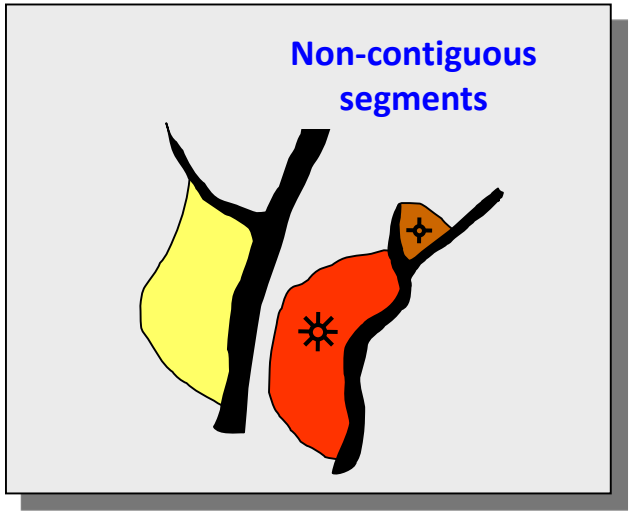
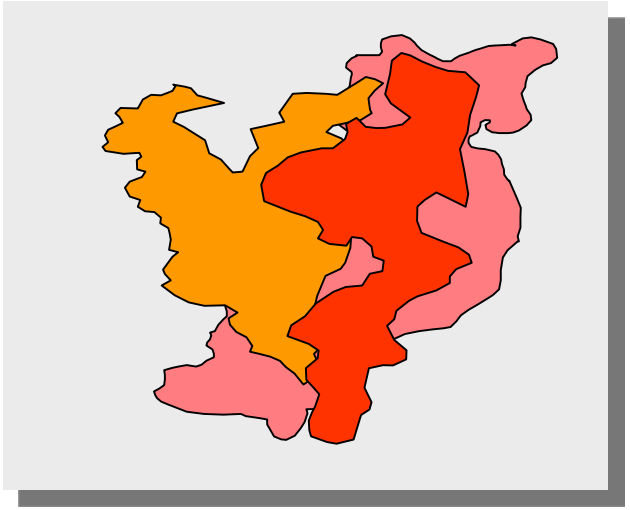
Feature Complexities – Status and Hydrocarbon Type



Stratigraphic Variation – Status or Hydrocarbon Type



Lateral Variation – Status or Hydrocarbon Type



Overlapping Hydrocarbon Pools

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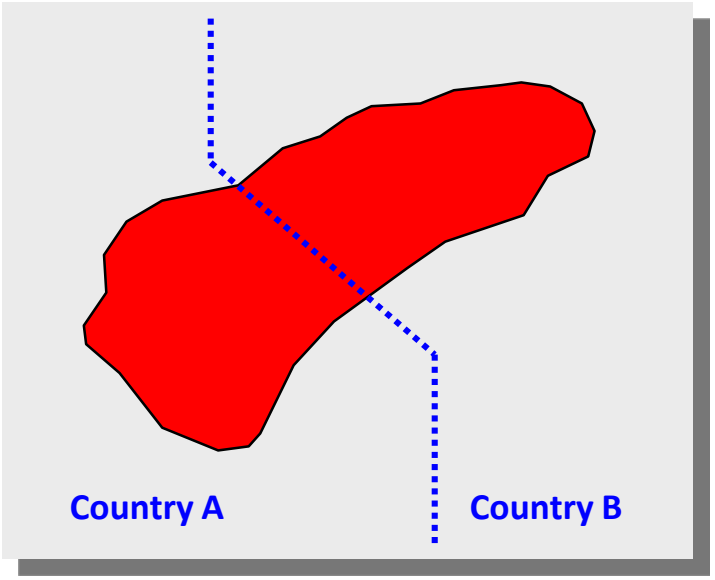
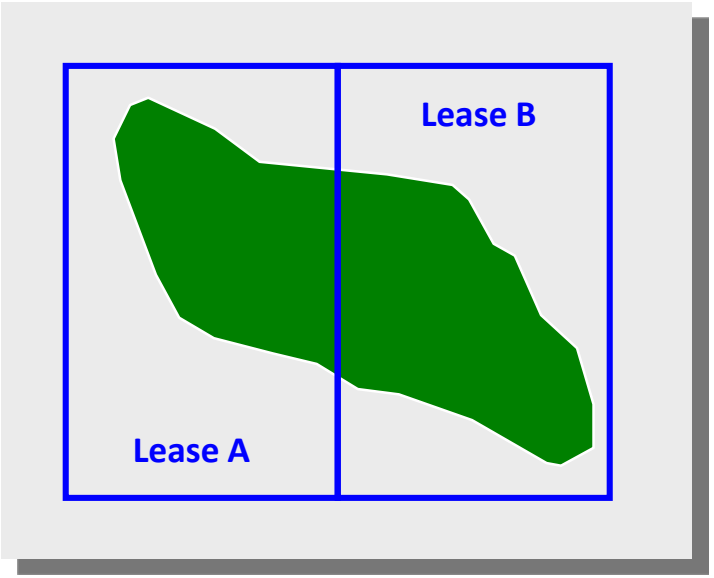
Feature Complexities – Non-Geologic boundaries



Non-Geologic Boundaries – Countries



Non-Geologic Boundaries – Lease Blocks

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After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Feature Database – Data Concepts

Basic data element is the Compartment

Can vary from a single reservoir in one fault block to an entire field

Compartments characterized by:

Geographic location, outline, and stratigraphic designation
Exploration, assessment, and opportunity classification
Hydrocarbon volume/type (field) or undiscovered potential (prospect)

Compartments aggregated using 4 level hierarchy:

Compartment - Reservoir (or greater) - Field analysis

Chronostratigraphic Aggregation - Sequence - Prospect analysis
Assessment Aggregation - Play Maps - Regional analysis
Closure Aggregation - Total Closure - Business analysis

Aggregation of outline, stratigraphic interval, hydrocarbon volume and type, and classifications

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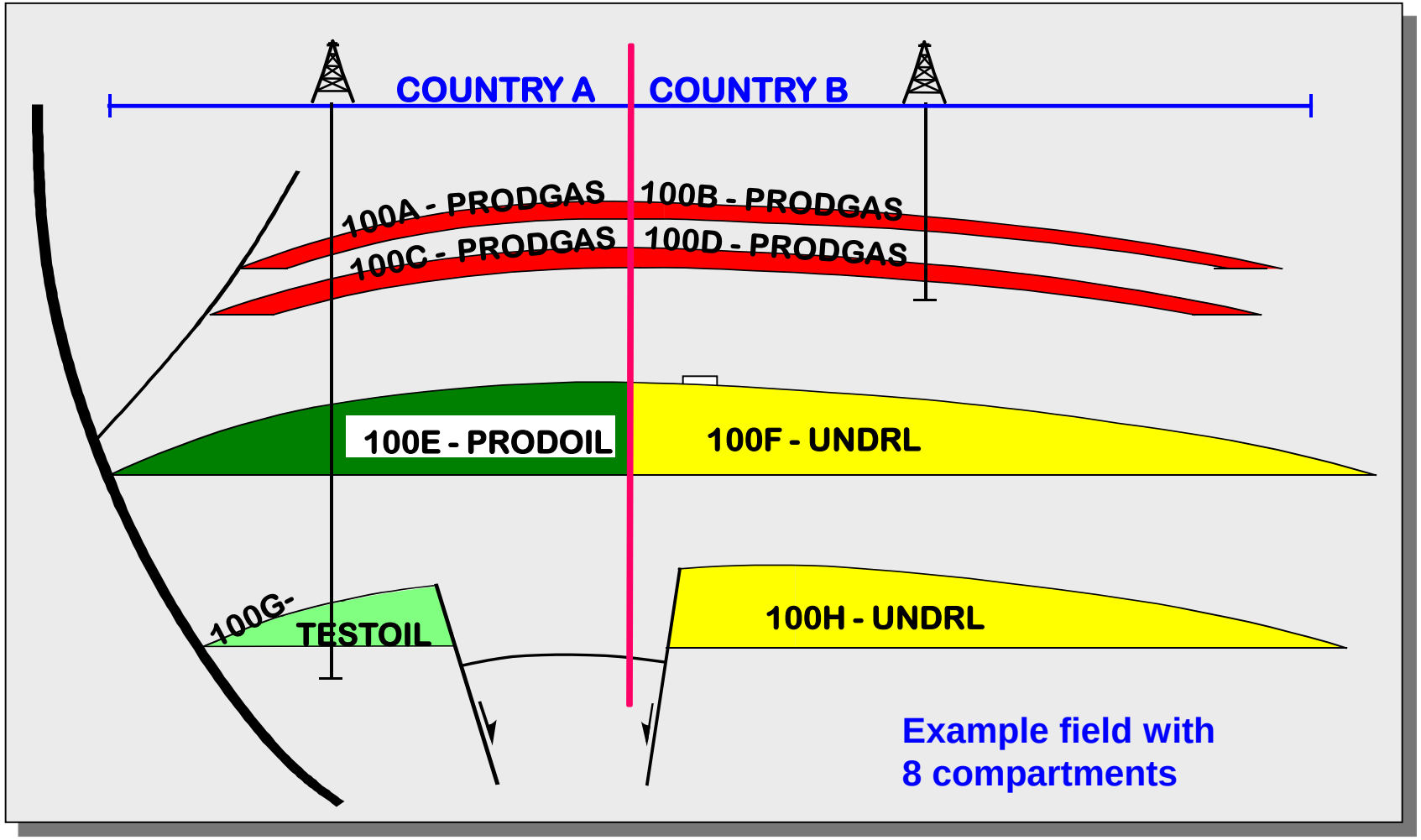
After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

General Closure Model (GCM) - Compartments



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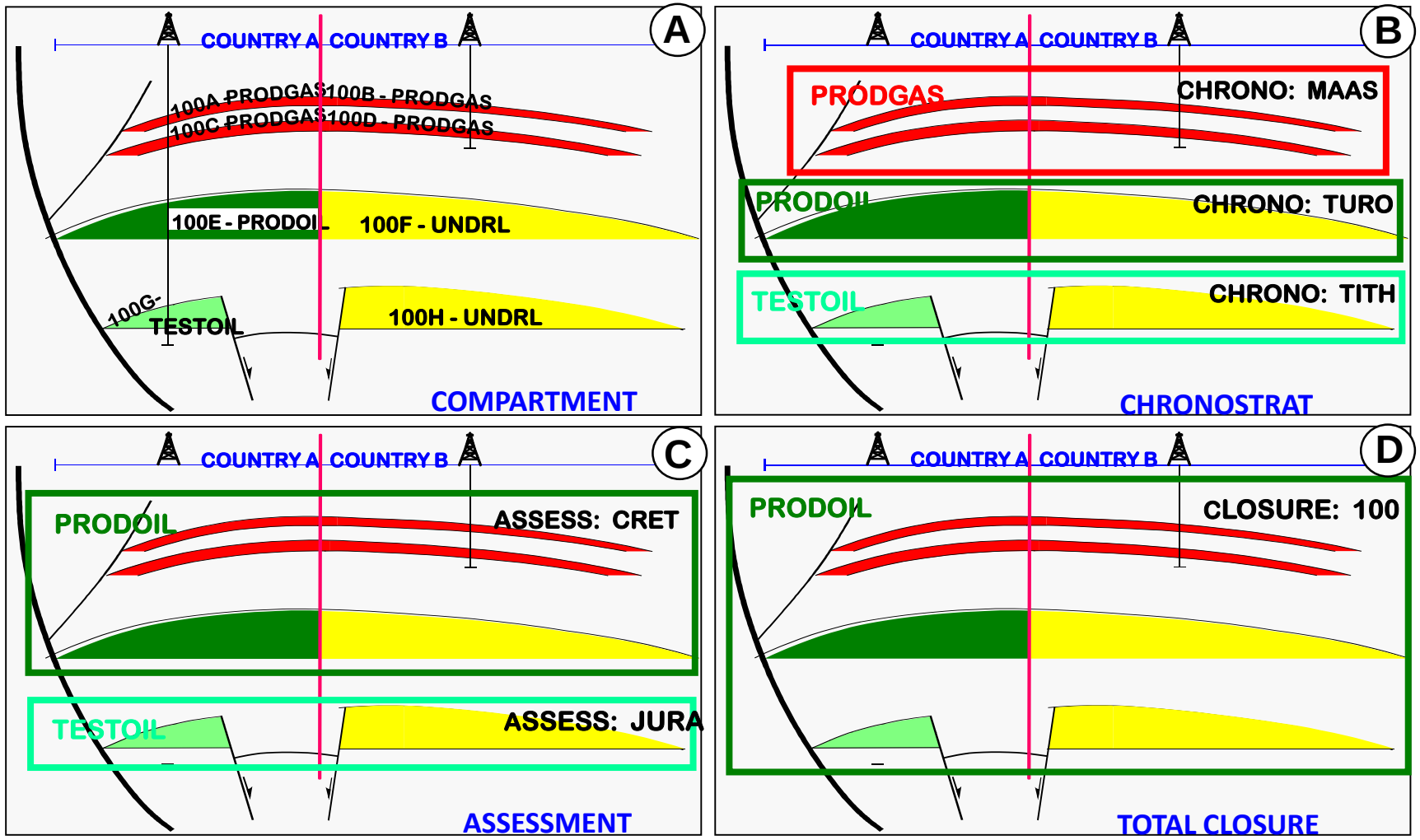
General Closure Model (GCM) - Aggregation

“Field”

“Prospect”

“Regional”

“Business”



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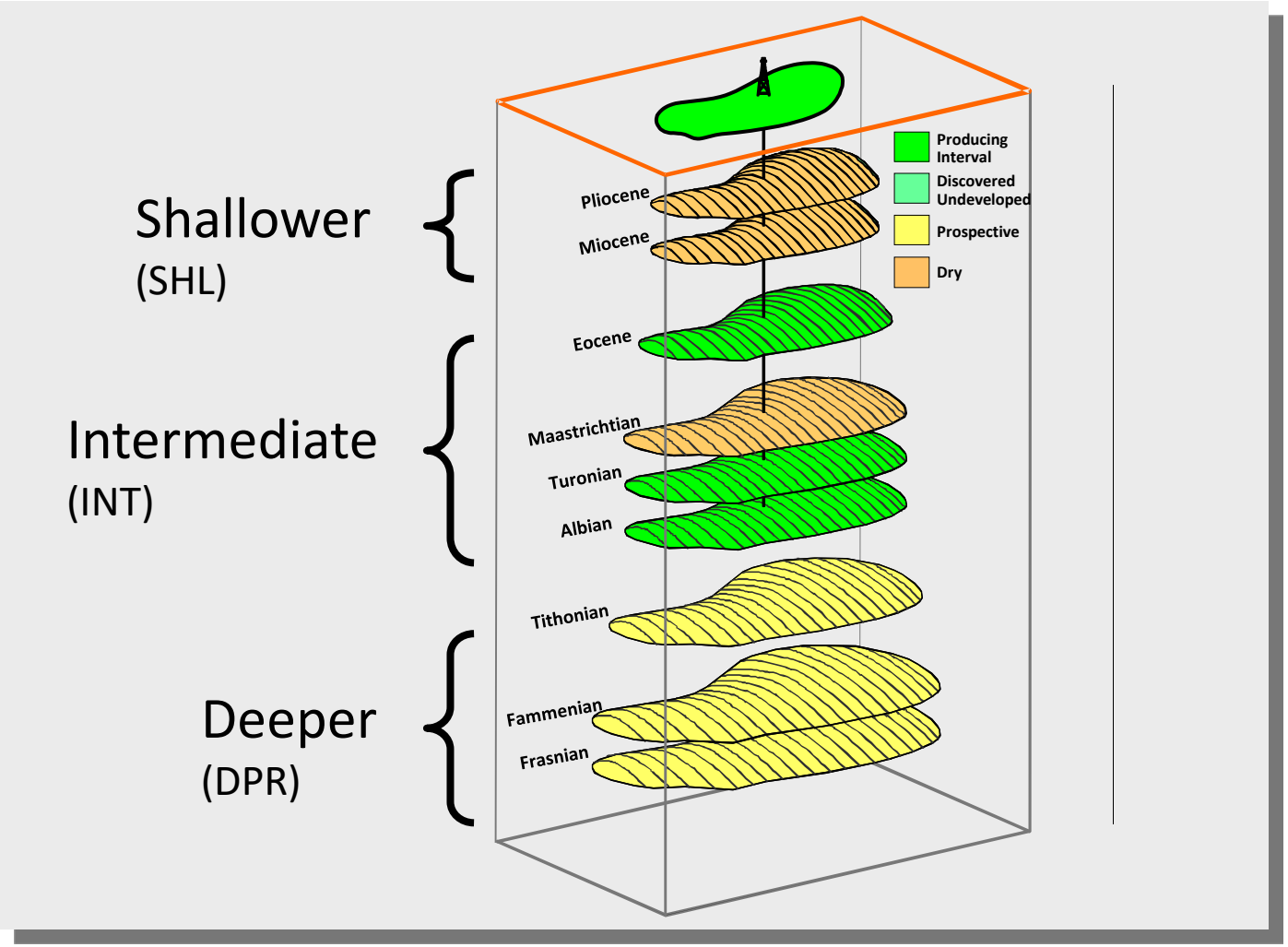
After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Classification Relative to Hydrocarbon Occurrences



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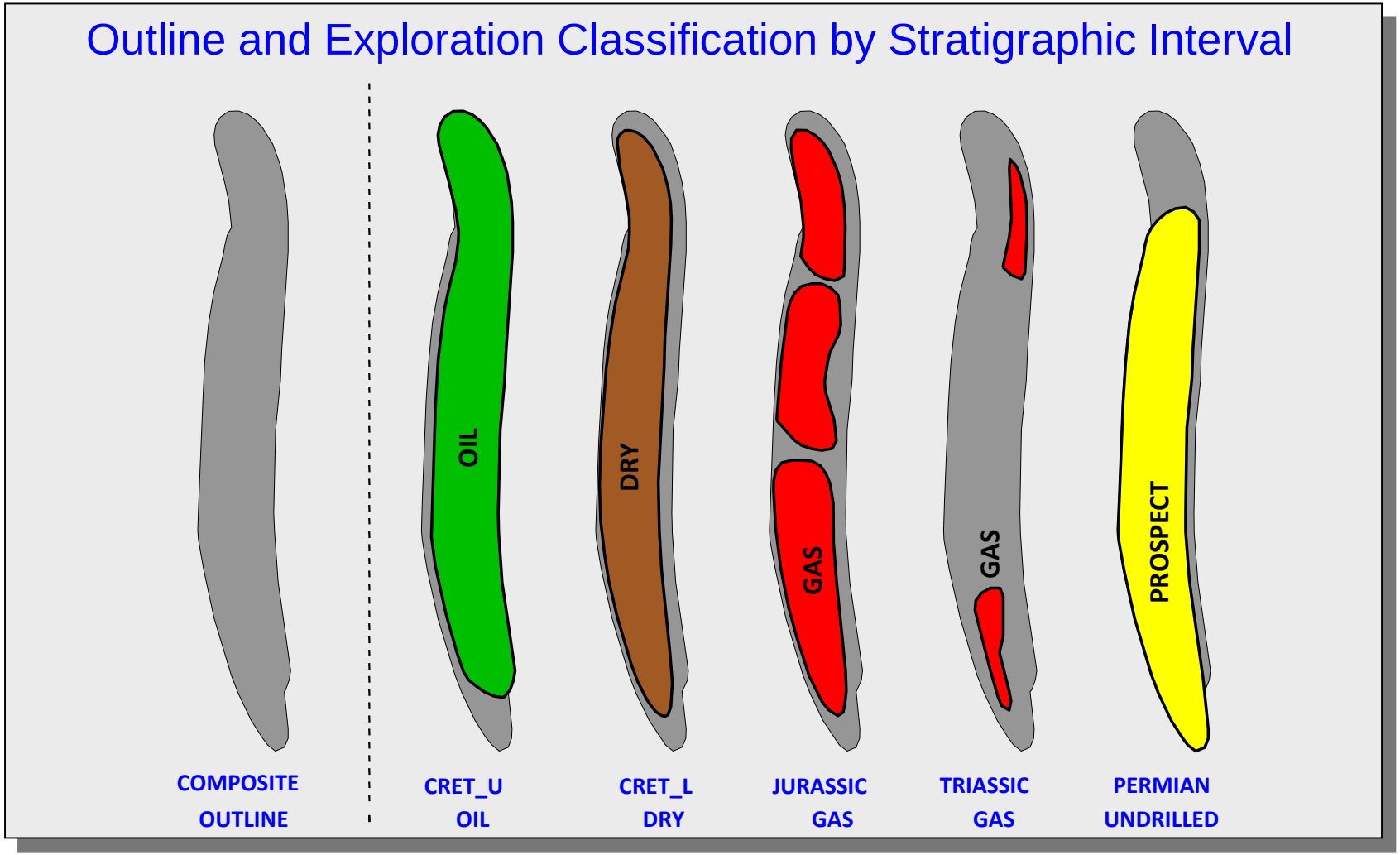
Single Feature Variation – Map View



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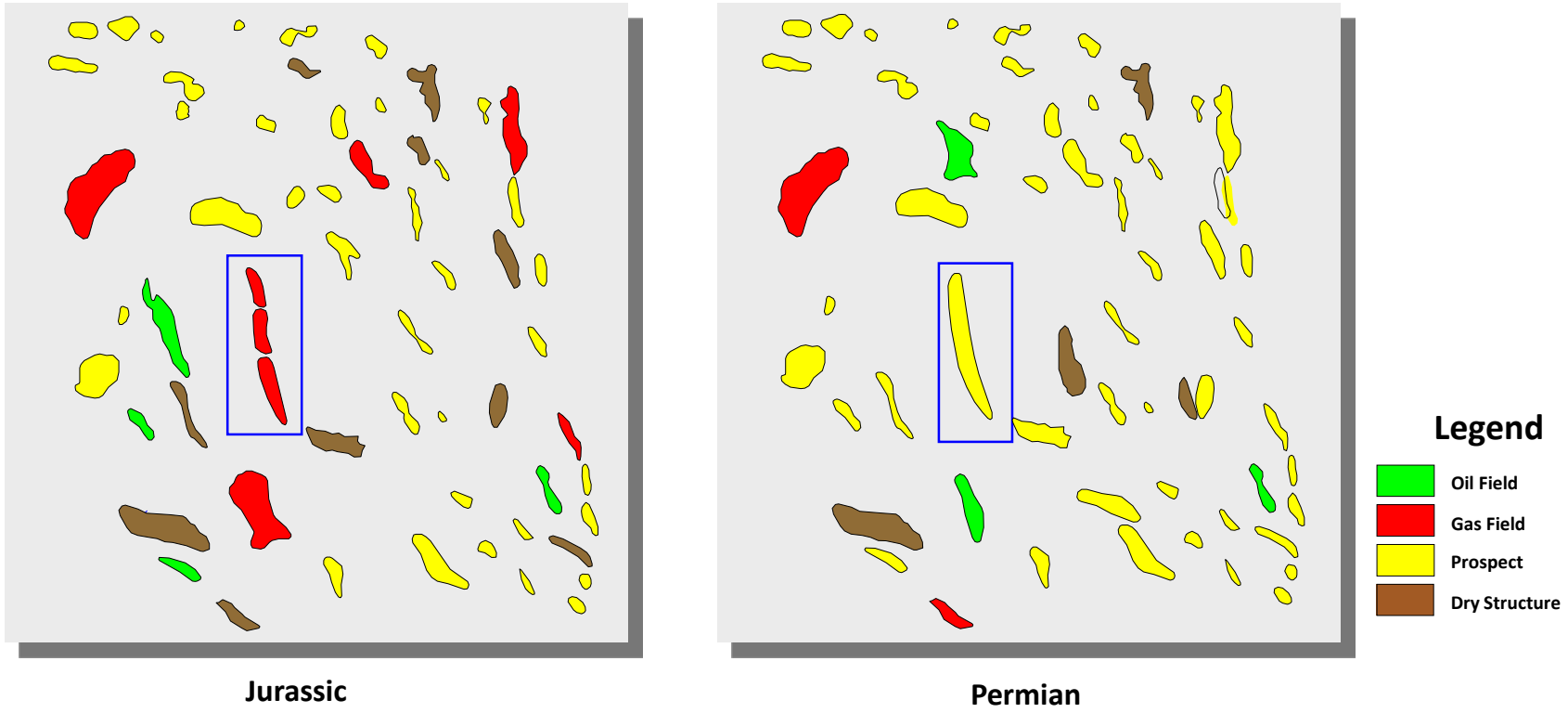
Feature Map by Assessment Interval



Feature information must be retrievable by assessment interval

➔ Note variations in closure presence, outline, classification, and hydrocarbon type

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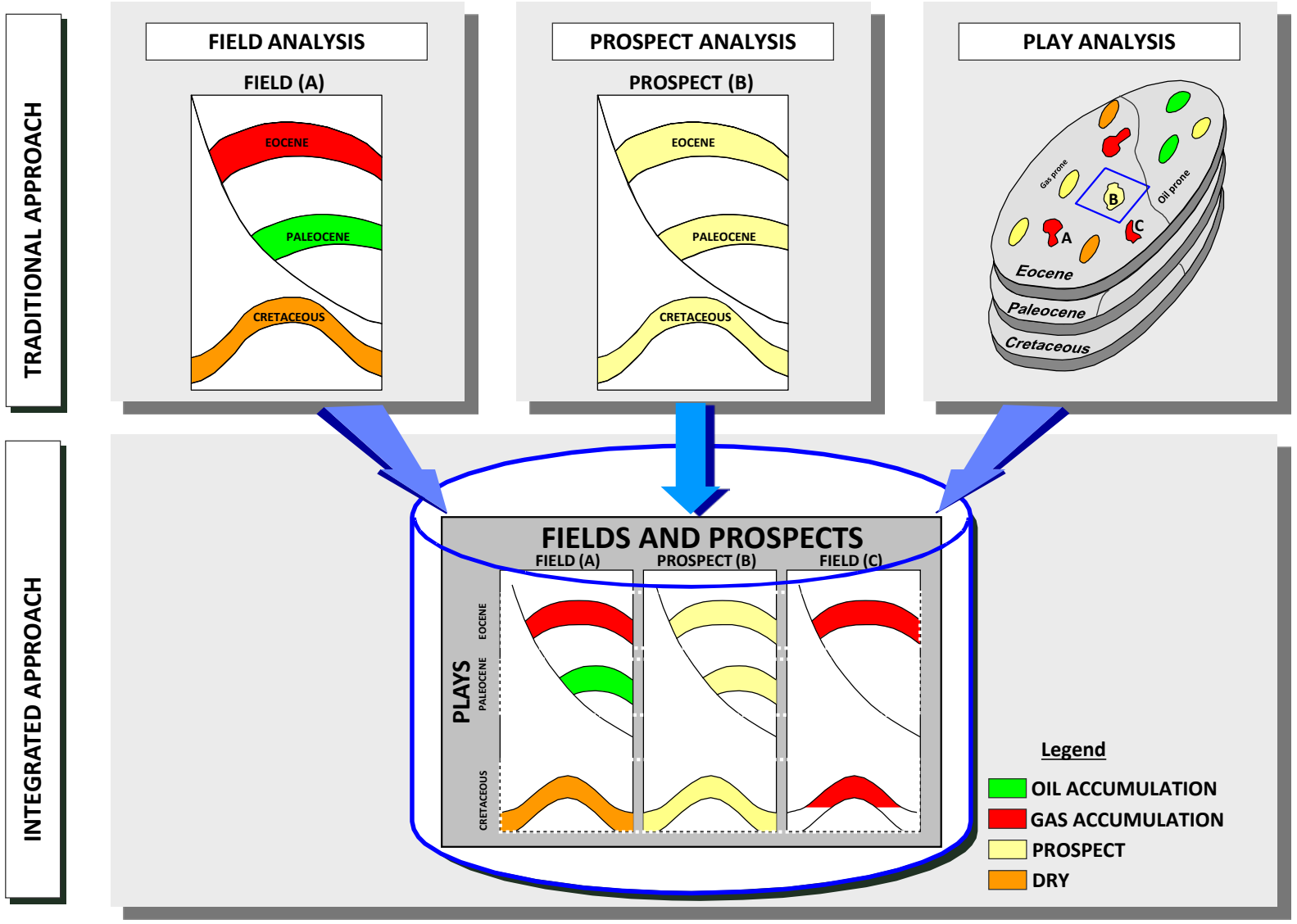
Integrated Database Concept



Supports different scales of analyses irrespective of the granularity of the inputs

After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Keys to Success

Database should accommodate a range of complexities specific to feature data

- Overlapping and non-contiguous compartments
- Stratigraphic and among-feature variation in level of detail
- Stratigraphic variation in exploration status and hydrocarbon type
- Best implemented as “3-D” database

Opportunity analysis involves more than simple evaluation of undiscovered potential

- Discovered undeveloped
- Enhanced recovery
- Integrated opportunity analysis

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After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Evaluation of Undiscovered Resources

- Geologic controls on hydrocarbon potential are inherently spatial and thus are well suited to GIS analysis
- Two basic hydrocarbon habitats
  - Discreet hydrocarbon pools – need to count, risk, and size potential hydrocarbon traps; need to account for water under hydrocarbon pools
  - Continuous hydrocarbon pools (e.g., shale gas, tar belts, coal bed methane) – need to account for resource density and extent, but no need to count discreet hydrocarbon pools

- ExxonMobil has implemented GIS-based tool boxes to evaluated these two hydrocarbon types
- Analysis performed by reservoir interval – a reservoir is a porous rock formation with sufficient pore space to contain producible hydrocarbons

ExxonMobil

Play Resource Evaluation

Integrating map-based geologic controls on prospect counts, risk, and size

Use of Geographic Information Systems in Hydrocarbon Resource Assessment and Opportunity Analysis

Kenneth C. Hood
Bernard C. South
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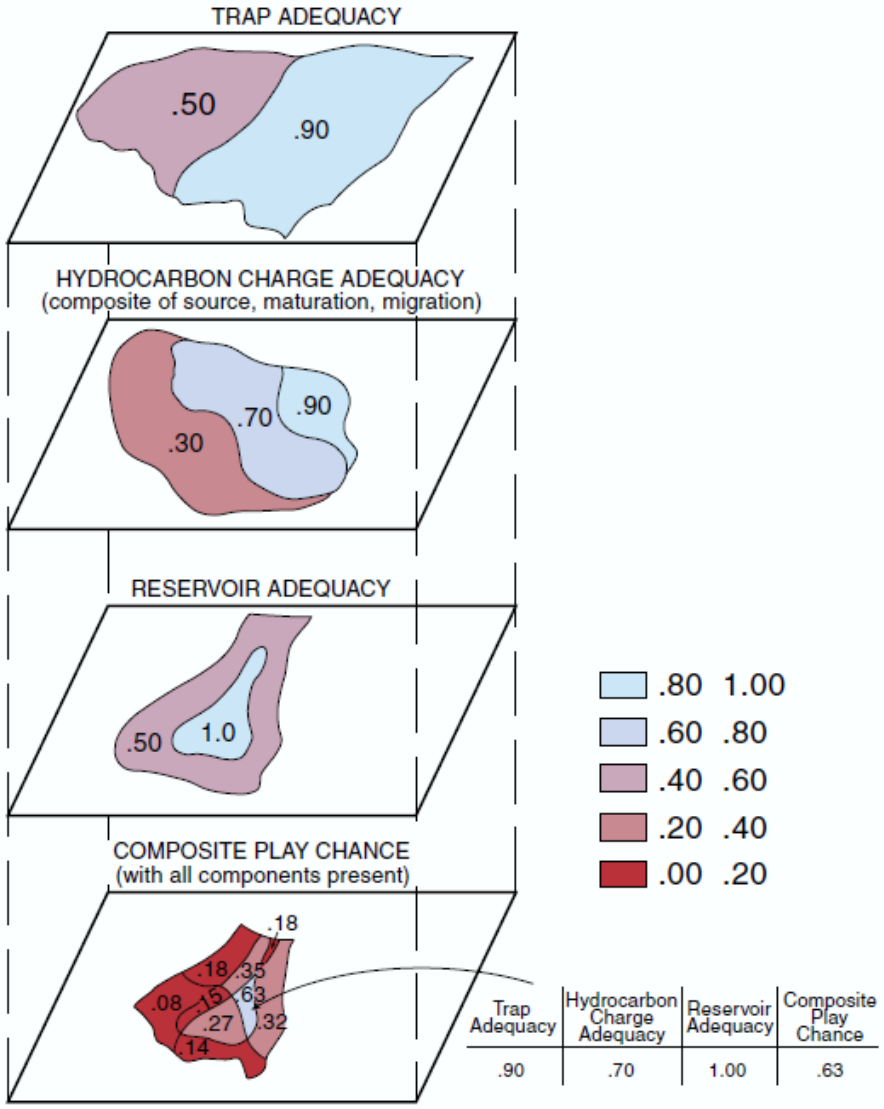
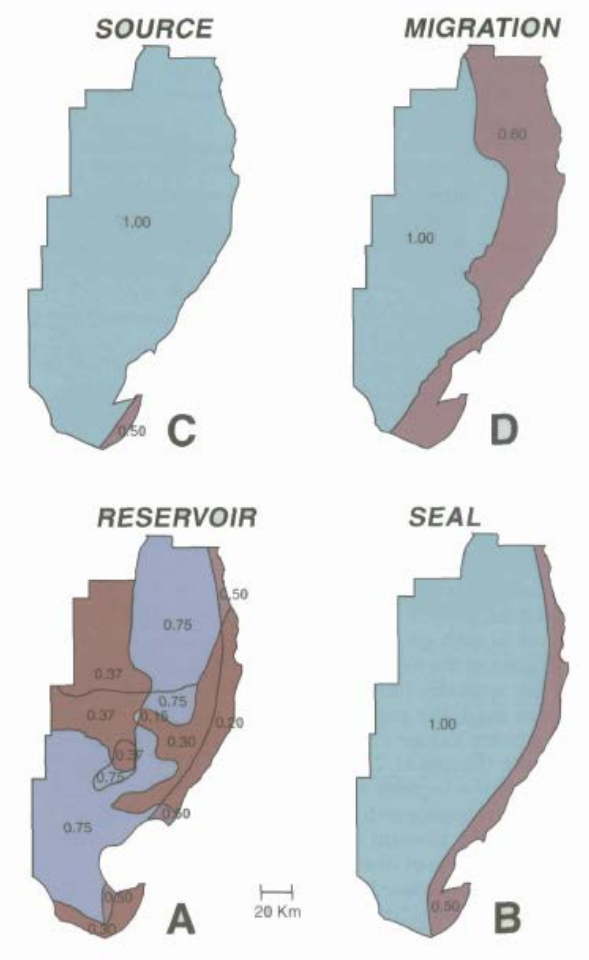
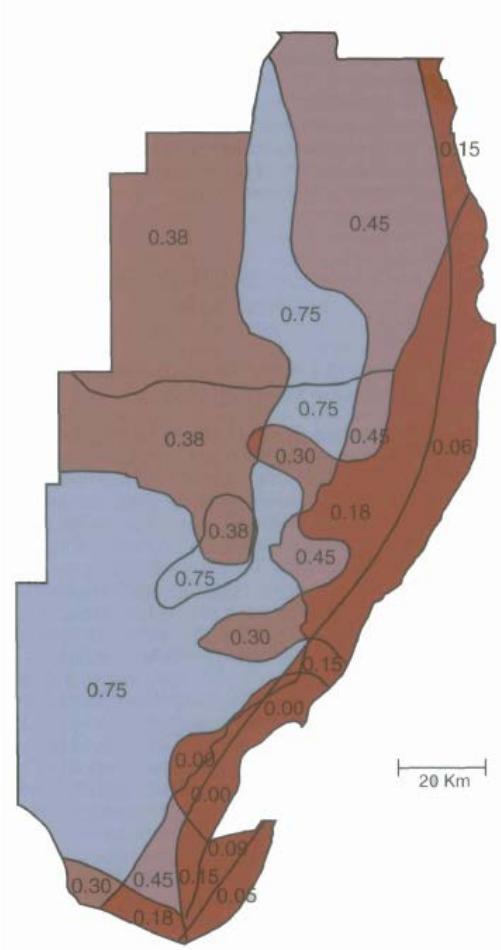
Otha D. Baldwin
William A. Burroughs
Exxon Exploration Company (now part of ExxonMobil)
Houston, Texas, U.S.A.

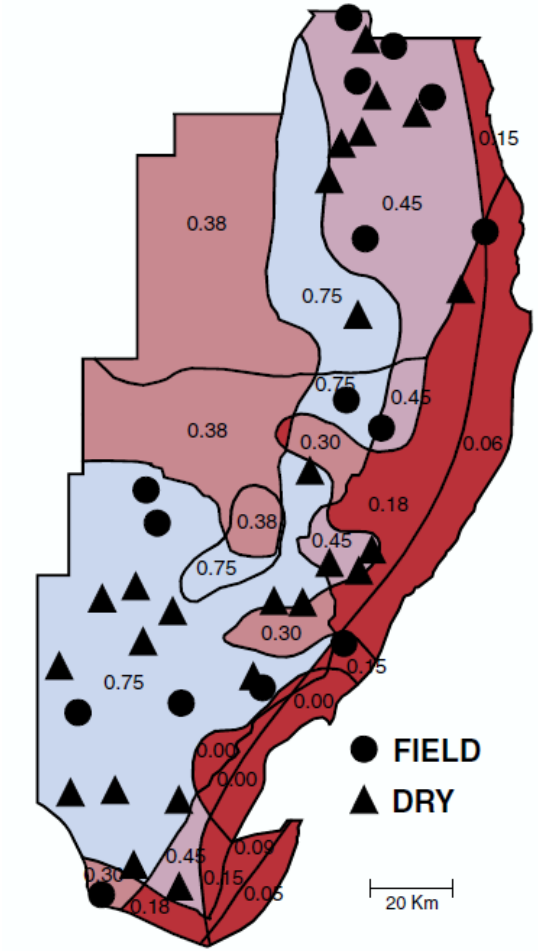


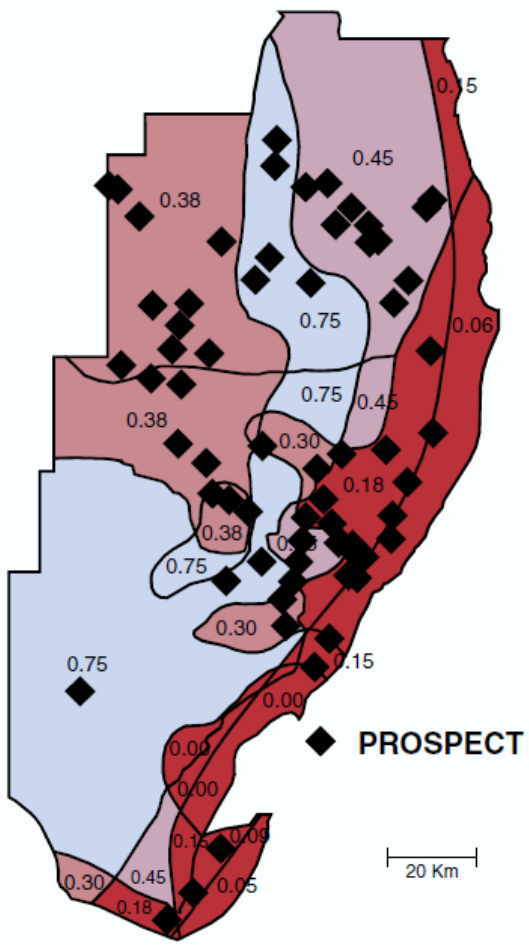
After Hood and others, 2000 (Use of geographic information systems in hydrocarbon resource assessment and opportunity analysis,)

GIS-Based Workflow









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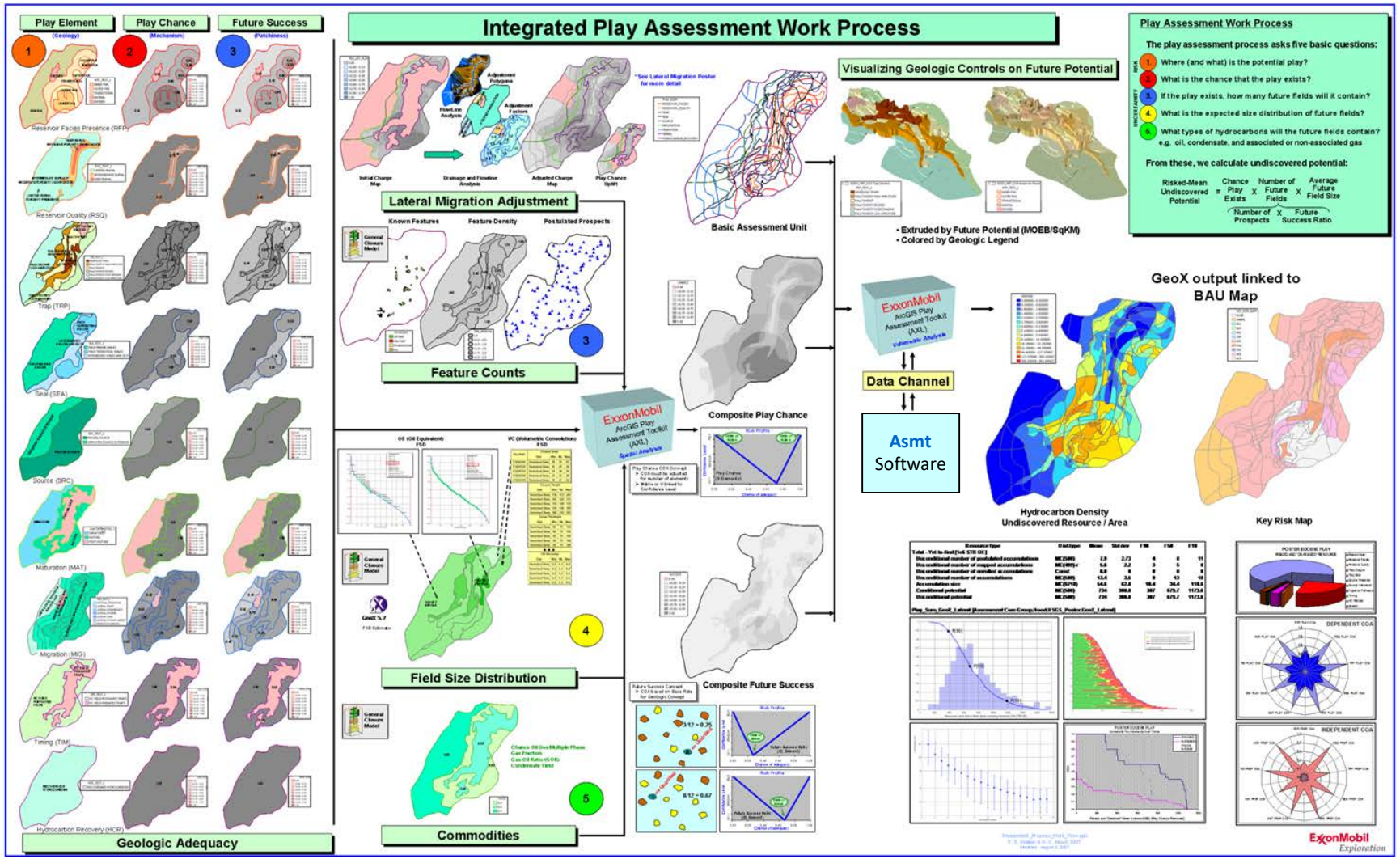
After Hood and others, 2000 (Use of geographic information systems in hydrocarbon resource assessment and opportunity analysis,)

Play Resource Evaluation Workflow

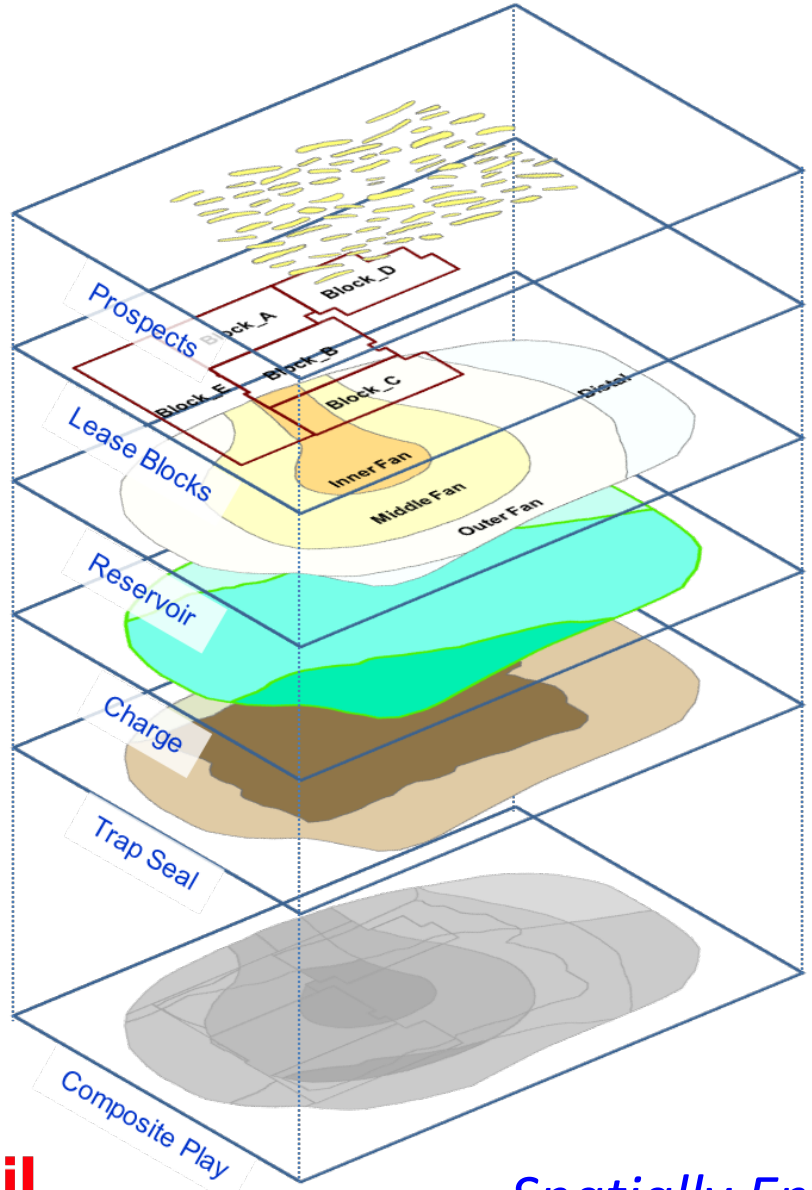
Play resource evaluation starts with the geology:

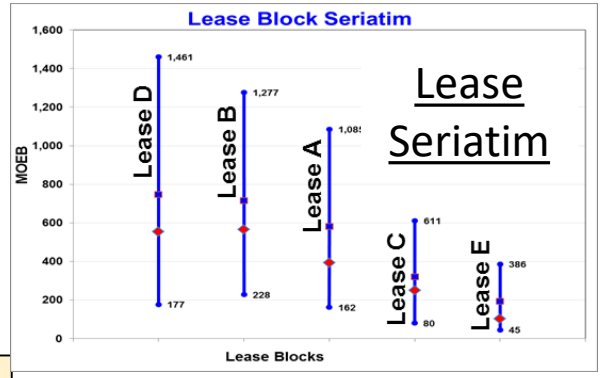
How does the geology influence the number, risk, and size of potential hydrocarbon accumulations?



After Hood and Walker, 2012 (Turning Regional Geologic Interpretations into a Hydrocarbon Resource Assessment)

Evaluation of Undiscovered Resources

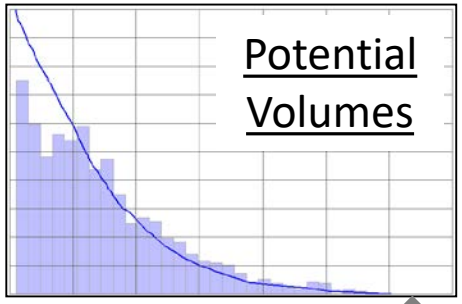


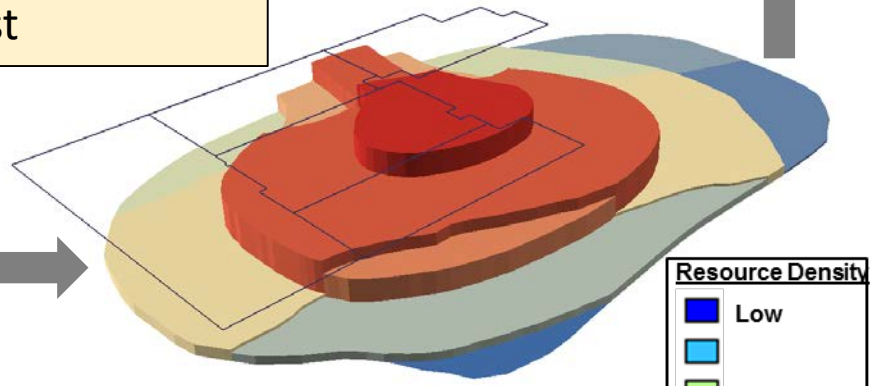


Business decisions:

Millions $$s

- Basin entry
- Pursue acreage
- Acquire acreage
- Mature prospects
- Divest





Play Potential

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Spatially Enabled Play Analysis

Opportunity Analysis

OPPORTUNITY ANALYSIS

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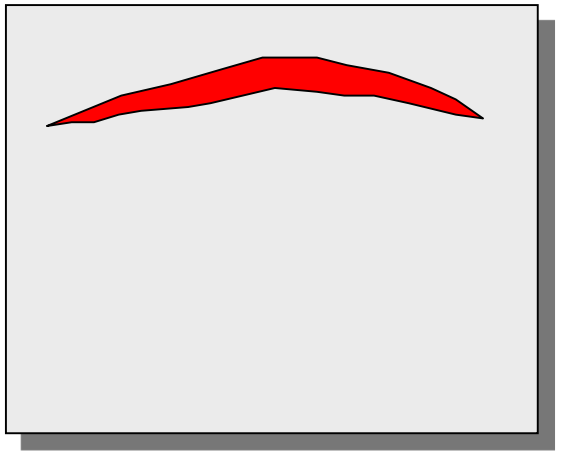
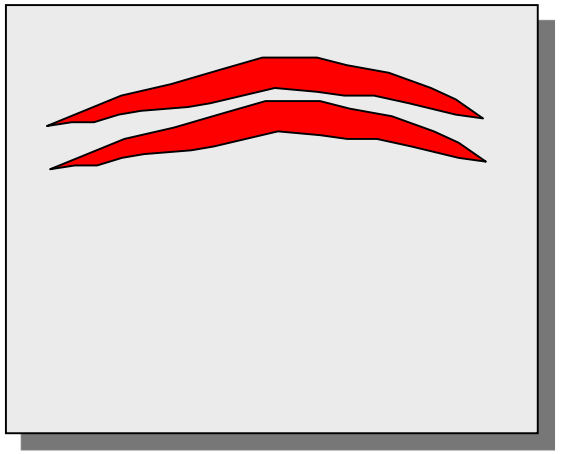
After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

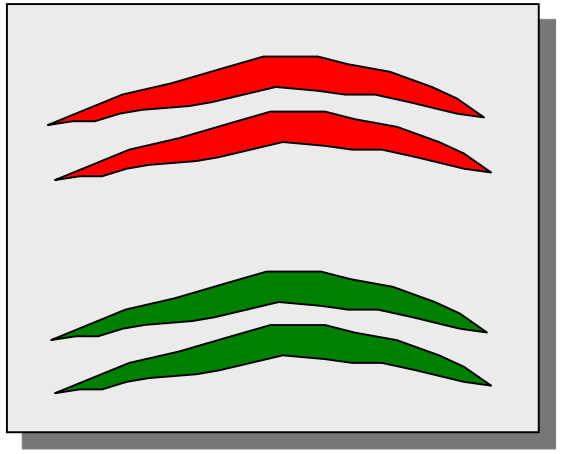
Opportunity Analysis – Resource and Potential Density



Single Pay



Stacked Pays



Stacked Plays

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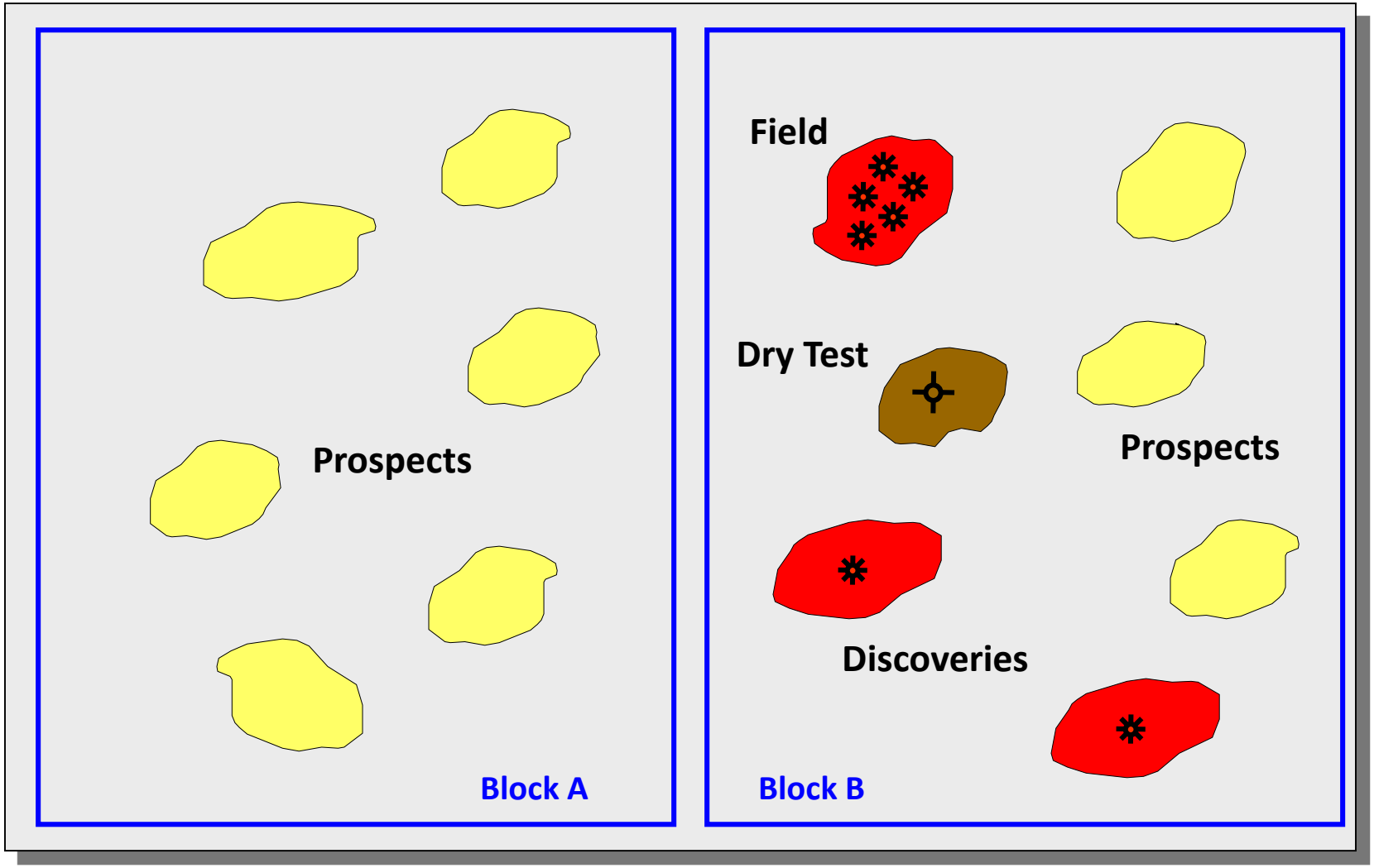
After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Which Block is the Best Opportunity?



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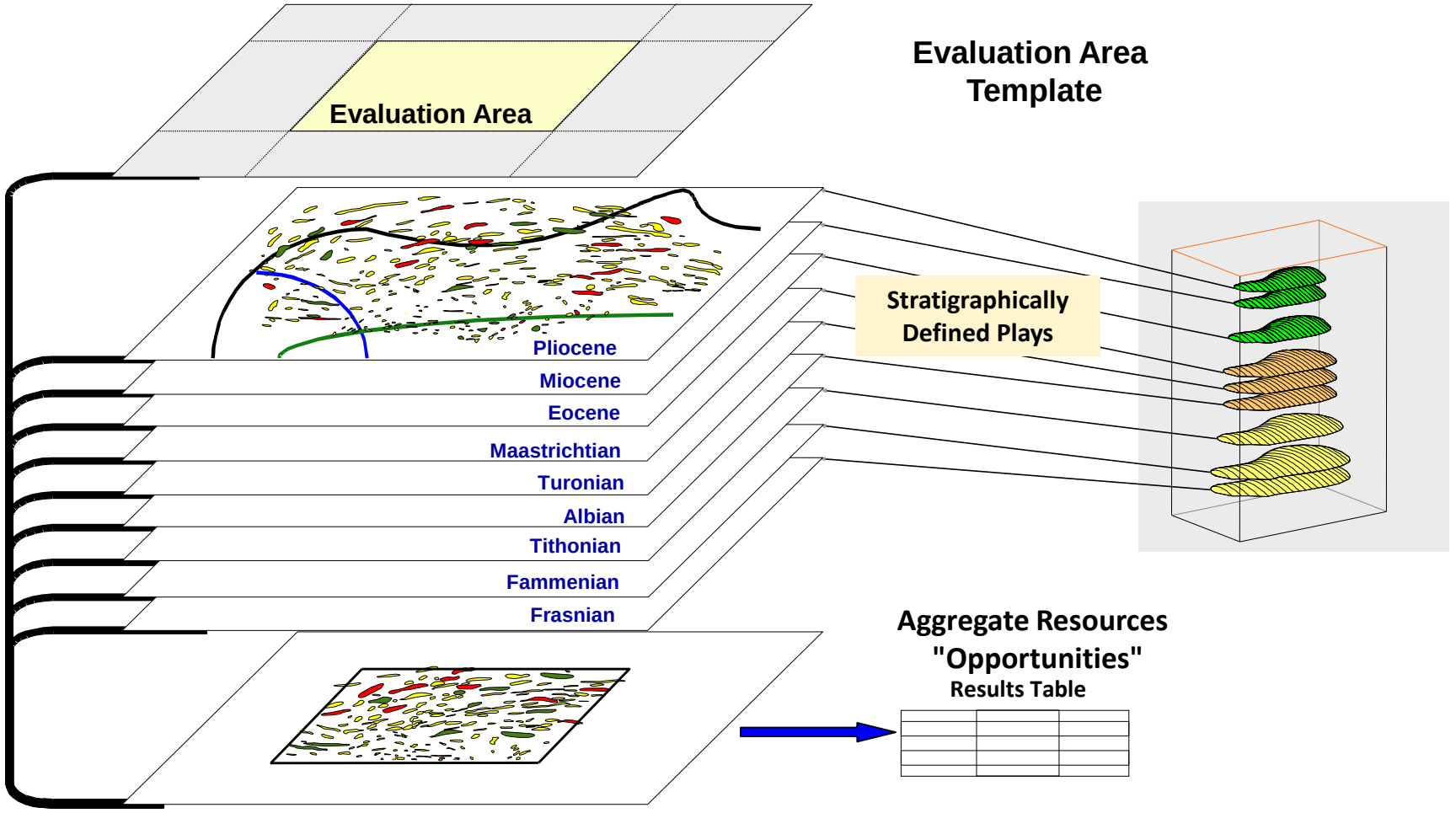
Multiple-Play Analysis



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After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

Summary

Geologic controls on hydrocarbon distribution are inherently spatial

GIS provides a powerful platform for managing opportunities and evaluating undiscovered resource potential

GIS supports more robust business decisions

After Hood and South, 2004 (ESRI Petroleum User Group Conference, Houston)

The End

Thank You

ExxonMobil